A

LECTURE

ON THE

PERPETUAL MOTION.

Haud facilè inventum perpetuum-mobile purum artificiale; haudquaquam quod fieri] non poteſt:

BERNOULLI.

Comme il eſt très-poſſible qu'un corps monte plus vîte qu'il n'eſt deſcendu; c'eſt ſur quoi je fonde ma preuve de la poſſibilité du Mouvement Perpetuel.

'sGRAVESANDE.

PART THE FIRST.

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MDCCLXXI.

ADDRESS

TO THE

PROFESSED PHILOSOPHICAL

CRITICKS.

GENTLEMEN,

I Should have taken earlier notice of the honour done me in your periodical lucubrations, had I been leſs indifferent to literary attacks, or could any body give a better reaſon than myſelf for diſregarding the cenſure of anonymous reviewers. Yet, finding it a very general opinion that men only affect to deſpiſe, and turn their backs on, the ſhafts they cannot repell, I am induced, againſt my inclination, and much againſt the dictates of my pride, to expoſtulate with you a moment on the inconſiſtency and injuſtice of your remarks on my account of the automaton, or ſelf-moving wheel, of Orffyreus.

I was in hopes the very reſpectable authorities and explicit evidence, on which I reſted the veracity of the fact, would have had more weight with men ſo confeſſedly open to conviction as yourſelves: all it ſeems to have had on you, being to induce you to ſcoop out the marrow of my pamphlet for the entertainment of your readers, and to leave the bare bone to be picked by my bookſeller.—But of this I do not complain. The republic of letters is ever in a ſtate of civil warfare; in which every man, being an enemy to his neighbour, takes the ſpoil of his goods for lawful plunder. Indeed, were it otherwiſe, and the genus irritabile vatum more peaceable creatures, it would be ſtill much the ſame with you. Being pirates by profeſſion and the public indulgence winking at your occupation as warrantable, you would doubtleſs think, with the highwayman in the play, there is no harm in labouring in your vocation.—What I do complain of, is, that having thus rendered my publication uſeleſs to me, my publiſher and the public, you ſhould proceed to treat me as if I were an ignorant viſionary, capable of weakly deceiving myſelf, or a deſigning impoſtor capable of wilfully deceiving others.

You are, ſome of you indeed, pleaſed to pay me the compliment of ſaying, you have the higheſt opinion of my abilities as a writer. But is not this ſtrangely inconſiſtent? Can you have an high opinion of the abilities of a writer, capable of impoſing on himſelf, in one and the ſame purſuit, for fifteen years together? A caſtle-builder? A miſtaken projector?———Of what ſort of ſtuff, for heaven's ſake, do you, wiſe critics, take good writers to be made? There was a time when you, or your predeceſſors, profeſſed as high an opinion of my abilities as a metaphyſician. Have I betrayed any want of metaphyſical capacity ſince? Or is it becauſe I have occaſionally miſemployed myſelf in tagging rhimes, tranſlating novels, ſcribbling comedies, or, for want of a ſufficient independency in toiling like yourſelves, invitâ Minervâ for worſe than Egyptian taſk-maſters: is it from all this you infer I can know nothing of the ſubject, to the knowledge of which I was in a manner bred, and which I have made the conſtant ſtudy of my life? Really, Gentlemen, if you thus lightly pronounce and retract your opinion of writers and writings, the public will ſoon learn to have no higher opinion of you than is entertained by thoſe who are already in your ſecret. So much for your conſiſtency.

I charge you with injuſtice in ſo raſhly giving your ſanction, however inſignificant it may prove, to the powerful prejudice which ſo generally prevails againſt the practicability of a diſcovery of confeſſed and univerſal utility. For, give me leave to tell you, how juſt ſoever may be your pretenſions to ſcience in general, you have by no means taken the pains to qualify yourſelves to be competent judges of the perpetual motion in particular. If, then, it be deemed an inſtance of injuſtice and cruelty to attempt, through prejudice to blaſt the hopes of induſtrious ingenuity, employed in the production of a puerile play or frivolous farce; the compoſition of which, whatever drudgery it may prove to men of confined talents, cannot be the labour of any length of time to a writer of abilities: yet if this, I ſay, be thought cruel and unjuſt, how much more unjuſt and cruel muſt it be deemed to endeavour to fortify prepoſſeſſion againſt the painful application, profound ſtudy and patient perſeverance, exerted in the proſecution of a ſeries of expenſive experiments, as I have ſaid, for near fifteen years together; and thoſe in the very prime and pleaſurable part of life?

When the object of ſuch a purſuit alſo is conſidered as uſeful to the public, it is not only injurious to the individual who hath thus devoted his youth, his health and even his means of ſubſiſtence to their ſervice; but to a whole community, that might expect to profit by his having made ſo laborious and, it is preſumed, laudable a ſacrifice. For the ſake of the public, for your own ſake, then, Gentlemen, let me prevail on you to look a little farther into this matter before you proceed to confirm your dictatorial deciſions on a ſubject, which you have ſo very, very, ſuperficially conſidered.

ſidered. Reflect that, whatever may be your diſpoſition towards me, it will be prudential with regard to yourſelves, to promote, as far as lies in your power, a candid and impartial diſcuſſion of my pretenſions; ſince, if I ſhould make them good, you will thence avoid the mortification of becoming hereafter the objects of ridicule; and if I ſhould not, you will have the triumph of ſeeing me the more compleatly ridiculous. In the mean time there is no danger of the world's being impoſed on; it is too well armed by its own prejudices to need any caution from you, even if the private emolument I propoſe to myſelf did not depend, as it entirely does, on the advantages of which my diſcovery may prove to the public.

I am,

GENTLEMEN,

Your humble Servant,

Jan. 24, 1771. W. KENRICK.

** Such readers of the following Lecture, as have not been auditors and may be desirous of seeing the experiments exhibited in its recital; will, on sending their address to the author, or the publisher, be furnished *gratis* with tickets of admission for that purpose.

The plates will be delivered with the third and last part of the Lecture.

APOLOGY.

IT was my original deſign, Gentlemen, to have given you the trouble of but one attendance on this lecture: but the doubts and objections, that have been ſtarted ſince the publication of my Syllabus, have reduced me to the neceſſity of letting them go unreſolved, or of enlarging my diſcourſe, if not beyond the bounds of your patience, beyond the abilities of an indifferent ſpeaker, ill qualified as unaccuſtomed to recite in publick.

To give the greater ſatisfaction, therefore, on a ſubject ſo much neglected, and of courſe ſo little underſtood, I ſhall enter into a more minute diſcuſſion of it than I at firſt intended, but which, I find by repeated intimations from thoſe to whoſe judgment I pay a particular deference, the curioſity of my auditors may require.

The mere exhibition of what is called a ſelf-moving machine, without a diſplay of its mechaniſm, or the principles on which its motion is begun and continued, could produce no conviction; would gratify no curioſity.

The fate of Orffyreus and his machine is a proof of this. Scarce fifty years ago that whimſical mechanician exhibited a perpetual motion at Heſſe Caſſel; the conſtancy of whoſe operation was experienced, for many weeks under the moſt exact caution of the Landgrave of that principality; whoſe teſtimony of ſuch operation, as well as in favour of its conſtruction, (to the ſecret of which he was admitted) was given in the moſt explicit and determinate form.

And yet, becauſe Orffyreus would not diſplay the mechaniſm of his machine, without the previous aſſurance of a premium of 200,000 florins (near twenty thouſand pounds) or becauſe he would not, or could not diſcover the principles on which it acted, his pretenſions were neglected; his machine was deſtroyed by his own hands; and his life made a ſacrifice to the chagrin attending his diſappointment.

Twenty years had he racked his brains for invention; worn his hands with labour, and expended a patrimonial competence with parſimony, in proſecuting his deſign. And, when ſucceſs inſpired the hope of reward, he found his ingenuity ſuſpected of impoſture and his induſtry rewarded with contempt. He died mad: a terrible example to all future projectors and particularly to pretenders to the perpetual motion!

Happy indeed is it for ſociety (though often peculiarly unhappy for themſelves) that projectors never take warning.

One would hence be apt to think that, as they ſay of poets, they are born ſuch and are impelled by a fatal neceſſity to encounter poverty, contempt and even death itſelf, to attain the object of their purſuit. It is otherwiſe difficult to account for ſuch amazing perſeverance as that of Orffyreus in ſpite of innumerable diſappointments, contradictions and railleries. To ſtand the butt of ridicule for twenty years together, argues a degree of fortitude or obſtinacy, call it which you will, almoſt incredible: yet ſuch was the fact and ſuch was the ill fate of Orffyreus.

Whether any of his ſucceſſors in the ſame purſuit will meet with a better, on the like preſumption, is at length to be determined. One ſpecies of our predeceſſor's merit, however, I preſume myſelf at leaſt entitled to, that of perſeverance; it being now near fifteen years ſince I firſt engaged in this undertaking: which I have ſince purſued with almoſt unremitted aſſiduity, and that not only at a conſiderable waſte of time and expence, but under the conſtant mortification of hearing it equally ridiculed, by thoſe who do know, and by thoſe who do not know, any thing of the matter.

One

One concluſion, however, was very naturally to be hence inferred; that, either a man muſt be invincibly ſtupid, not to have in all that time diſcovered his error, or that ſuch error muſt lie much deeper than to be ſo univerſally obvious, as is pretended.

The truth is, that the public in general, and even men of ſcience, conceiving the ſubject unworthy attention, have not ſufficiently conſidered the nature of it, to determine with certainty any thing about it. I could give a very pleaſant relation of the ſtrange miſconceptions I have met with, on this head in perſons of the firſt rank and reputation in the world of ſcience. But as I know they were rather the effect of prepoſſeſſion than incapacity, their future conviction will be a ſufficient reprehenſion of their paſt prejudice.

It is indeed generally ſuppoſed, and as confidently affirmed, that the mathematicians have publiſhed demonſtrations of the impoſſibility of a perpetual motion. But I can ſafely take upon me to affirm that, no ſuch demonſtration was ever publiſhed by any. Within theſe twelve years paſt, the mathematicians who deny the poſſibility of a perpetual motion, have been repeatedly and publickly called upon, both in the foreign and Engliſh prints, to produce a ſingle inſtance of theſe demonſtrations. They have not done it. They could not do it.

They might have produced, indeed, the demonſtrations of Huygens, De la Hire and others, to prove, as Deſaguliers very properly expreſſes it, the fallacy of the ſchemes of moſt of the pretenders to the perpetual motion. But this was all. They proved nothing more; and this was ſo far unneceſſary, in that the fallacy evidently appeared on the diſcovery of the principle, on which they were founded.

This was done in the laſt century by the celebrated Marquis of Worceſter, in the preſence of the King and his Court, at the Tower; by the exhibition of a wheel, ſo contrived that, in revolving on its axis, it carried up ſeveral weights nearer its centre on one ſide, than they deſcended on the other.

The

The ſcheme was plauſible, and to appearance practicable: but, though the wheel was polite enough to turn about while his Majeſty was preſent, it could not be prevailed upon to be ſo complaiſant in his abſence.

The court, however, was amuſed and perſuaded: the Marquis was looked upon as a very extraordinary man (as he certainly was,) though, out of his celebrated century of inventions, I think much the greater part died with him. The mathematicians avenged themſelves of the ſhort triumph of the miſtaken Marquis; but were equally miſtaken themſelves, in thinking they had routed the problem, or that, in hunting down the jackal, they had deſtroyed the lion.

The perpetual motion ſurvived. It had ſtill its advocates. Profeſſor 'sGraveſande and John Bernoulli maintained its practicability; the former giving his teſtimony in favour of Orffyreus's machine after a long and ſcrutinous examination.

It is not twelve years ſince this teſtimony was republiſhed, by Dr. Allaman, the preſent profeſſor of natural philoſophy at Leyden; whoſe own opinion, given at the ſame time, is alſo greatly in favour of the diſcovery. It is even ſome years later that a diſſertation, ſtill more in its favour, written, if I am not miſtaken, by the celebrated de Gorter of Peterſberg, appeared in the philoſophical tranſactions of Haarlem.

But to what purpoſe you will probably ſay, Gentlemen, is a reference to authorities in a matter, that ſeems ſo eaſily decided?

To very little purpoſe indeed, unleſs to ſhew that even the prejudices againſt this diſcovery are not quite ſo general among men of ſcience, as among men of no ſcience is generally imagined.

But you will ſay, perhaps, if the perpetual motion be practicable and the mode of rendering it ſo diſcovered, the ſimple exhibition of the machine in motion, would at once remove doubt and enforce univerſal conviction, without farther trouble of explanation.

Not

Not ſo, Gentlemen. I have already obſerved that this was far from being the caſe with Orffyreus. It is true the mechaniſm of his machine was totally concealed; but, had it been otherwiſe; unleſs, with the diſplay of its conſtruction, he had at the ſame time illuſtrated its principles of action, and thence demonſtrated the certainty of its continuing the motion, impreſſed on it; ſuch an exhibition would have ſerved only to amuſe the ignorant, and perſuade the credulous.

Thus, ſhould I content myſelf with the mere exhibition of the experiment I propoſe (demonſtrative as it will be to thoſe who are previouſly acquainted with the principles on which it is made) it might convey no conviction to others. For, unleſs I could comprize the ſpace of a twelve month, within an hour, how could the mere motion of a machine for that hour prove its capacity of moving, in like manner, a whole year? Or how ſhould a model, merely raiſing a pound weight, prove a larger engine capable of raiſing up an hundred, or a ton? And yet, if it would not, the diſcovery muſt be nugatory; and might, however plauſible, be after all illuſive.

But I can have no intereſt in perſuading the public into a futile belief of having diſcovered what, being of no uſe to the world, can be of no advantage to me. My end is not to amuſe or perſuade; but, with due deference, to inform and convince.

To remove every cauſe of objection, therefore, I muſt beg leave to treſpaſs on your patience, by expatiating ſomewhat more at large on the theory of this diſcovery, than would on a leſs neglected topic be altogether pertinent to a practical diſcourſe.

It is, however, with the more propriety I preſume on this method, as the diſcovery to which I pretend has not been (as frequently happens) the effect of mechanical accident; but the premeditated reſult of mathematical reaſoning and phyſical experiment.

In conformity to this mode of inveſtigation, I ſhall not take up your time merely in confuting a number of contradictory pleas, deduced a poſteriori from

equivocal facts; but proceed to elucidate the principal arguments a priori, that prove the practicability of a perpetual motion to be the neceſſary conſequence of the known and eſtabliſhed laws of nature. Were this impracticability indeed real, as it is ſuppoſed, I ſhall ſhew that neither could you, Gentlemen, have done me the pleaſure of attending this lecture; nor ſhould I have had the honour of reciting it.

INTRODUCTION.

On the Nature of Motion in general.

MANY and various have been the opinions of philoſophers, reſpecting the Nature of Motion. It has been urged, indeed, of late, by ſome eminent writers, that all attempts to define it, are vain and futile; it being utterly impoſſible to define a ſimple idea.

With ſubmiſſion however to great authorities, I muſt take upon me to obſerve that, the idea of motion, as ſuggeſted by phyſical experiment, is very far from being a ſimple idea. It is a complex notion, compoſed of ſeveral ideas, viz. that of the reſiſtance of the moving object, of the medium through which it moves, and of the time it takes up in moving. For we can form no compleat conception of motion abſtracted from either of theſe.

To give a clear definition, therefore, or explain the nature and cauſe of motion in general, it is neceſſary to illuſtrate the ſimple ideas, of which that of motion is compounded.

Metaphyſicians indeed have uſually defined motion to be change of place, or a paſſage from one place to another. *

But

* This was Epicurus's definition.——That of Ariſtotle, *actus entis in potentia quatenus in potentia*, is condemned by Mr. Locke as abſolute jargon.——Leibnitz cenſures, as imperfect, that of Sturmeus, *Succeſſiva rei motæ in diverſis locis exiſtentia*; and ſubſtitutes another equally defective, in calling it *continua loci mutatio*. In all theſe caſes however it is plain the philoſophers were endeavouring to give the definition of an abſtract idea and not a palpable phænomenon.

But change of place, or the mere tranſition of any thing from one place to another, as that of thought, for inſtance, by the imagination, is not motion.

Some philoſophers, indeed, and Mr. Colden in particular, have ſpoken of the motion of things, deſtitute of the power of reſiſtance: but ſuch motion muſt be merely ideal. If the moving object have not ſome eſſential reſiſtance, independant of its motion, its change of place would be impalpable as that of thought; or rather it could not change its place at all. Place is peculiar to reſiſting objects and ſuch only are the objects of phyſical ſcience. I now feel by its reſiſtance, that ſomething exiſts between my fingers. That reſiſtance is now gone, and there is nothing in its former place.

Again, mere change of place may be inſtantaneous. I can as ſoon tranſport myſelf in imagination to York-Minſter, as to St. Paul's Cathedral; to St. Peter's at Rome, as to Notre Dame at Paris: but the difference of time would be very conſiderable, in the removal of the ſwifteſt animal to thoſe different places.

In conſtituting actual motion, it is neceſſary that the moving object ſhould poſſeſs ſome kind of force, or impulſe; in conſequence of which it reſiſts every other object of the like nature, in the line of its direction; and that not merely in proportion to its velocity; but in a ratio compounded of that velocity and the quantity of ſuch reſiſtance. A ſmall body in motion will not reſiſt an oppoſing obſtacle ſo much as a great one of the ſame kind, moving with the ſame velocity.

Every moving object muſt therefore be a reſiſting ſubſtance. But what is this ſubſtance? And what the cauſe of its reſiſtance? Here, Gentlemen, I muſt beg leave to draw the line of definition.

It is admitted, that we cannot define a ſimple idea; and ſuch is that of phyſical ſubſtance, immediately ſuggeſted to us by the ſenſation ariſing from the reſiſtance of palpable objects.

To inveſtigate the primary cauſe of this reſiſtance, I ſhall not attempt. It is ſufficient, for the preſent purpoſe, that we have the evidence of our ſenſes

that ſuch objects exiſt. It had been well if natural philoſophers had been always content to found their ſyſtems on ſuch evidence. We ſhould then never have heard of ſolid particles of matter, a perfect vacuum, or the motion of inactive elements by immediate impulſe; none of which are deducible from the ſenſes; and natural philoſophy is confined to the inveſtigation of things whoſe exiſtence is to be rationally inferred from the evidence of ſenſe.

A philoſopher indeed has lately ſtarted up, who, affecting to be ſhocked at the abſurdities of the ideal ſyſtem of Locke and Hume, has undertaken to reform it on the principles of common ſenſe; in conſequence of which he affirms, that our notions of the qualities of bodies are none of them acquired by the ſenſes: but that we are led to conceive them (he cannot tell how) by our nature and conſtitution.* By our nature and conſtitution to be ſure we are; for theſe conſiſt of the union and operation of the ſenſes. Indeed this ſame philoſopher refines ſo far as to ſuppoſe we might have been ſo made, as to taſte with our fingers, to ſmell with our ears, and to hear with our noſes.—Riſum teneatis! What a pity he did not add too, underſtand with our elbows! This he might certainly as well have done as have aſſerted, that the judgment ſometimes precedes ſimple apprehenſion, as if the truth of a propoſition might be known, before the terms of it are underſtood. But if this be common ſenſe, it is common ſenſe to ſay a man may ſee without eyes, hear without ears, and judge without underſtanding.

This method of reaſoning is ſo far from improving philoſophy on the principles of common ſenſe, that it brings it back again to its ancient and exploded ſtate of occult qualities and innate ideas.

I ſhall proceed, therefore, on the well-known and eſtabliſhed principles of experimental philoſophy; concluding, that all our ideas of the properties of bodies are derived from the ſenſes, and that ſuch evidence is ſufficient proof of their exiſtence.

* See Reid on the human mind, Chap. vi. Sect. 21.

Now there never was, nor ever can be, a ſingle experiment made, from which we may juſtly infer, that inactive elements of any abſolute dimenſions, or, as they are commonly called, extended, inert, impenetrable particles of matter, exiſt in nature.

That reſiſting objects exiſt, we feel, and know. But that their reſiſtance is the effect of the abſolute impenetrability of their conſtituent parts, we neither can feel, nor know. The penetrability of palpable objects (and ſuch only I repeat again, can come under the ſcrutiny of phyſical experiment) is merely relative.

By experience we learn that ſome bodies are comparatively more ſoft or hard, penetrable or impenetrable, compreſſible or incompreſſible than others: but, when we ſhall have found the hardeſt and moſt compact body in nature, we ſhall only have found a body that is impenetrable to others leſs penetrable. We have no means to make trial of its own abſolute impenetrability; for, even the ſubſtance of ſoft clay is as impenetrable to ſoft clay, as that of iron to iron. And the body which appears hard and impenetrable as iron to the gentle preſſure of a ſoft hand, would appear ſoft and penetrable to the forcible impulſe of a hand as hard as iron.

When Sir Iſaac Newton therefore, inferred from the extenſion, hardneſs and weight of palpable bodies, that the primary homogeneous elements of which all bodies are conſtituted muſt be extended, ſolid and heavy too, he reaſoned illogically; as well as took that for granted which he ſhould have proved. We find, ſays he, that ſeveral bodies are hard; and argue that the hardneſs of the whole only ariſes from the hardneſs of the parts: whence we infer that the particles, not only of perceptible bodies, but of all others, are hard likewiſe.

With all becoming deference, however, to the opinion of this great philoſopher, it was but a weak way of arguing. Might not one ſay with equal propriety, ſqueezing a ſoft piece of ſponge or other ſimilar ſubſtance in one's hand, that we find ſeveral bodies ſoft and elaſtic, and therefore their primary particles, as well as thoſe of all others, are ſoft and elaſtic too? Such argument

is,

is, indeed, altogether inconclusive. Palpable bodies are all compounds; and their various properties the effects of the combination of their parts, or the specific modification of the whole.

Were it otherwise, compounds would be mere aggregates of simples: nor could there be any specific difference between them. The truth is, as already observed, that all the terms by which we express the properties of palpable objects, are relative to the organs by which we perceive them. Nothing is absolutely solid or impenetrable; but all things are big or little, hard or soft, light or heavy, as they bear a comparison with each other, and stand related to the organs of sense: which form the common standard, by which we judge of their respective properties.

The misfortune is, that the conclusion we deduce from experiment, is frequently a mistaken one. It is not thence really and logically deducible.

There is nothing in which people in general are more mistaken than in the evidence of a single sense. Even ocular demonstration, generally supposed the most convincing of all others, is of all others the most delusive.

Almost every one imagines himself capable of seeing what no body can possibly see. Had we no other evidence, than that of sight, it would be impossible for us to distinguish between a superficies and a solid; between things near and afar off.

Length and breadth are objects of sight; thickness not. We see only surfaces, and by the arts of perspective might be constantly deluded. It is the same with the other senses. Thus when I feel a resisting substance; by the immediate touch, I perceive nothing but the sensation of that resistance, and can truly infer nothing from it, but the existence of a property, or power, of resistance in the perceptible object. Here therefore we should stop.

But our philosophers proceed to infer that this object must be an extended solid substance. It must have dimensions, say they, length, breadth and thickness. And yet by the simple and immediate touch I perceive neither. By moving

moving my hand, indeed, along its edges and over its ſurfaces, I gather by reflection, the idea of its extenſion.

From the comparative evidence alſo of my other ſenſes, I find that moſt bodies, palpable to the touch, have the appearance of ſolidity: they exhibit a determinate form and figure. But I obſerve, that this apparent ſolidity is in many bodies adventitious and circumſtantial; dependent on the qualities of the medium, in which they exiſt.

Bodies of ſlight tenacity appear, in cold countries, in the ſolid form of wax, butter, tallow and the like; and aſſume in warm climates the fluid appearance of oil. Water, a perpetual fluid under the equator, is ſolid ice in Nova Zembla. Even quickſilver will become ſolid, in a medium of artificial cold, as has been experienced at Peterſburg.

On the other hand, ſo tough and heavy a body as lead, diſſolves in a medium moderately warm, and even ſteel itſelf becomes fluid, in the highly rarified medium of an heated furnace.

A reflection on theſe circumſtances, hath induced ſome philoſophers to queſtion whether fluidity or ſolidity be, properly ſpeaking, the natural ſtate of bodies. And this, however ridiculed by ſome, would have been a queſtion worthy of philoſophers, if the terms, natural ſtate, had borne a more explicit and determinate meaning.

But, be this as it may, when I ſee thus the ſame body at one time and place, and under ſome circumſtances, a ſolid, and, at another time, or in another place, and under other circumſtances, a fluid; what reaſon have I to conclude ſolidity eſſentially connected with reſiſtance? Certainly none. At the ſame time, however I find, that under all circumſtances, in all times and places, the reſiſtance of the body remains. Though varied in its mode of appearance, its quantity is ſtill the ſame. Incloſe it in any containing veſſel and it will equally reſiſt compreſſion in a fluid as a ſolid ſtate, it will move, or reſiſt any moving body, with the ſame force as a ſolid of the ſame dimenſions and denſity. The

The ſimple reſiſtance of body, therefore, is an eſſential quality inherent in every moving object or phyſical ſubſtance.

It is alſo the only eſſential quality we can aſſign it: all that we can philoſophically affirm of the primary elements, being that they are moveable powers of reſiſtance.

Some of you, Gentlemen, will perhaps find it difficult to form the idea of a power abſtracted from ſome ſubſtratum, or extended ſubſtance, in which that power ſubſiſts. But I can aſſure you that inability is more owing to your being ſo accuſtomed to the notions of void ſpace, and impenetrable matter, than to any incapacity of conception. Mr. Locke ſays, it is as eaſy to form an idea of power in the abſtract as of ſubſtance; and indeed I ſhould think it is full as difficult to conceive the eſſence of an inactive, impenetrable ſubſtance of abſolute dimenſions, incapable of compreſſion and dilatation, as that of an active elaſtic ſubſtance of relative dimenſions capable of both. We do not preſume in general to impute dimenſions to the great firſt cauſe, and yet we cannot diſpute his exiſtence or omnipotence. It is indeed to be obſerved that phyſical principles are not founded ſo much on the perſpicuity of our ideas, as on the certainty of our ſenſations. They are more immediately deduced from the conceptions, however obſcure, of what we perceive, and thence conclude, really to exiſt, than on abſtract notions of nonentities or things of meer ideal exiſtence. We know that things exiſt only by their properties. We define their eſſence only by theſe properties; nor are we permitted, in natural philoſophy, to indulge the imagination, in forming conceptions of chimerical ſubſtrata, to which thoſe properties belong.

We feel and know that moveable reſiſting powers exiſt; but whether the action or exertion of thoſe powers be confined to certain determinate limits, within which their intenſity is fixed and abſolute, as in impenetrable matter, or whether they are capable of occupying a greater or leſs quantity of ſpace, with an intenſity proportionable to their dimenſions, as in elaſtic ſubſtances, are queſtions we ſhall be better able to determine, from conſidering the other component parts of motion.

To come to that of the place, or the ſpace in which the moving object exiſts. This is generally conceived to be mere vacuity, a phyſical nonentity; rather a privation, or negation, of exiſtence than any thing really exiſting.

But however juſtly we may reaſon on negative terms, in algebra and other branches of metaphyſics, we cannot admit negative principles in phyſics. Qualities, however occult in their eſſence, muſt be poſitive in their exiſtence. We cannot explain or account for animal perception; but that we do perceive, cannot be diſputed. At leaſt thoſe who doubt that they ſee, hear and feel, may be not uncharitably ſuppoſed to doubt every thing elſe. And it would be in vain to attempt their conviction.

Extenſion indeed, is not to be immediately inferred from the ſimple touch; but it is from the ſight. The length and breadth of any body, and the diſtance between any two bodies, is as viſible to the eye, as the ſurfaces of thoſe bodies themſelves, or as their reſiſtance is palpable to the touch. Space therefore hath as real an exiſtence as phyſical power, or reſiſting ſubſtance itſelf.

It may be objected that, if the magnitude of the reſiſting ſubſtance be merely relative, it would be reducible by a ſufficient force ad infinitum, and the whole univerſe be compreſſible into a mathematical point; in which caſe the extenſion of bodies, as well as their diſtance, would be annihilated, and of courſe no ſpace remain.

That the annihilation of phyſical power, or reſiſting ſubſtance, would annihilate phyſical ſpace, I readily admit: Nay that the accumulation of all ſuch powers or ſubſtances into one individual power or ſubſtance would annihilate motion. But, ſo long as they remain divided, ſo long as two ſubſtances coexiſt, though each ſeparately were confined to a mathematical point, and the addition or multiplication of cyphers in arithmetic amount to nothing, yet there muſt of neceſſity be ſome real extenſion, or poſitive diſtance, however ſmall, between them. They would otherwiſe not be two ſubſtances; not two mathematical points; but one.

If it were poſſible for two bodies to come into actual contact, without becoming really one, their two adjoining ſurfaces would conſtitute but one point or ideal plane of ſeparation.

Number and identity depend either on locality or ſucceſſion. It is impoſſible for two objects of the ſame nature to exiſt in the ſame place, at the ſame time. They muſt be either diſtinguiſhed by ſome poſitive diſtance of place, if they exiſt at the ſame time, or by ſome poſitive diſtance of time if they exiſt in the ſame place.

Hence it is plain that, were the potential elements of reſiſting ſubſtance even mere mathematical points, the coexiſtence of a prodigious number of them muſt neceſſarily deſcribe a vaſt extent of ſpace, even though the diſtance between each ſhould be ever ſo little.

And hence we ſee alſo that duration, the other component part of motion, hath as real an exiſtence, as either extenſion or reſiſtance. Indeed the tranſition of body from place to place, is frequently as obvious to ſenſe, as either the bodies themſelves, or the diſtance between them.

We are here alſo to obſerve that the limits of bodies form no part of their extenſion or place. Extended objects may be ſeparated by dimenſionleſs points; but dimenſionleſs points cannot be ſeparated, but by ſome real diſtance, or ſomething really extended. If the wall or partition were taken away, that ſeparates this room and the next adjoining, we ſhould either call it one room, or ſhould allow that the two rooms were divided only by their diſtance of place. But there would be no diſtance between the eaſt ſide of one and the weſt of the other. The weſt ſide of the one might nevertheleſs be at a conſiderable diſtance from the weſt ſide of the other; as the eaſt ſide of the one would be at the ſame diſtance from the eaſt ſide of the other. There would be alſo two points in the middle of each equally diſtant, which would determine the locality of the two rooms, or the diſtance of their reſpective places.

Thus the place of a dimenſionleſs point, is in that point; but the place of an extended ſubſtance, is in the centre of its dimenſions.

We

We are come then to this dilemma; either the reſiſting elements themſelves muſt be compreſſible only to a certain degree; that is into certain dimenſions, within which they cannot be reduced; or the diſtance between them, if reducible to dimenſionleſs points, muſt be abſolutely poſitive; a concluſion that, involving an impenetrable fluid, is equally repugnant to motion, with that of impenetrable matter exiſting in vacuo.

From the very phænomenon of motion itſelf, therefore, we are reduced to the neceſſity of concluding; that the elements among which it is originally generated, are elaſtic ſubſtances of a determinate power, limited as to their degree of compreſſibility, and doubtleſs alſo, as finite created beings, to that of their dilatation: within the bounds of which however, the intenſity of their reſiſtance or elaſtic force is, like that of all other elaſtic bodies, proportional to to their denſity, or the dimenſions they deſcribe.

As a Corollary of this propoſition it will follow that ſpace is a plenum; not of one ſolid impenetrable matter, but of innumerable elaſtic ſubſtances, mutually reſiſting each other; and conſtituting by their coexiſtence, an elaſtic fluid medium; ſimilar, if not exactly the ſame, with the ſubtile æther hinted at by Sir Iſaac Newton, and whoſe exiſtence is ſo fully confirmed by the electrical experiments of Dr. Hoadley and Mr. Wilſon. *

It will follow alſo, from the known properties of elaſtic fluids, that no change of place could be effected in ſuch a medium, but in time, as we ſee all motion is. And that motion, once generated in ſuch a medium, might be propagated and continued ad perpetuum.

On the other hand, were the moving elements abſolutely ſolid, inactive and heavy, exiſting in vacuo; they could neither be put in actual motion, nor, if poſſible to be put in motion, could that motion be long continued.

Sir

* Not that there would be no interſtices between the elements. This appears neceſſary as each element would aſſume a ſpherical form, and touch the contiguous elements only in a few points.

Sir Iſaac Newton himſelf, indeed, gives up the point with reſpect to the gravity of the primary elements; which, he admits, may be the effect of ſome mechanical impulſe: abiding only by the ſolidity, and vis inertiæ of thoſe elements, or their perfect indifference to motion and reſt. It was the admiſſion of theſe ſolid, impenetrable particles of matter into his ſyſtem, which reduced him to the neceſſity of admitting alſo of a vacuum. Without this, it would have been impoſſible for his elements to undergo that change of place, and in that manner, which all bodies evidently do.

With regard to their actual motion indeed, he did not pretend to account for it, otherwiſe than by an occult and inſtantaneous impulſe, arbitrarily exerted or impreſſed on them by the will of the creator. But I ſhall ſhew, that this could not be the caſe, conſiſtently with the known and eſtabliſhed laws of nature.

In the generation of motion among palpable bodies, exiſting in a reſiſting medium, the bodies at reſt are always moved with a velocity proportionable partly to the velocity and quantity of the body putting them in motion, and partly to the denſity of the medium in which they move: Being compounds, their velocity is generated between the component parts of each; for it is to be obſerved, that the parts of the one body do not all directly ſtrike againſt, or impell, all thoſe of the other. There are but a few of thoſe parts, that come immediately in contact, the reſt are ſucceſſively impelled and repelled by each other till the whole be gradually affected, the compound itſelf not actually changing its place, till all its component parts are equally impelled. And this is the reaſon, as I ſhall more fully explain hereafter, why bodies can in no caſe communicate more motion than they poſſeſs, and that even this muſt be equally diſtributed in the conflict among their component parts, before the whole body be put in motion.

The caſe however would be different in the original motion ſuppoſed to be given to a ſimple uncompounded element, equally indifferent to motion and reſt, exiſting in a perfect vacuum. For this, being ſolicited by a determinate impulſe on one ſide, and there being no reſiſtance to that impulſe in the element itſelf, nor from the medium on the other, it could not be diſpoſed to take up any time in paſſing from one place to another; but might, for any thing that

appears to the contrary, move a million of miles in any given time as well as a ſingle foot.

For, be the impulſe great or ſmall, being inſtantaneous and the element itſelf perfectly indifferent to motion and reſt: and, there being no reſiſtance in the medium, no proportionable velocity could poſſibly be generated. Nullity has the ſame want of proportion to one as to one million!

Lord Kaims whoſe acknowledged abilities were exerted ſome years ago in the illuſtration of this ſubject, ſuppoſes indeed, that the generation and communication of motion is in all caſes inſtantaneous. In analyzing the operation however, he is obliged to divide it into three ſucceſſive ſteps. But it is a contradiction in terms to ſuppoſe any action to be at once inſtantaneous and gradual.

This ſuppoſition is alſo founded on the miſconception of the abſolute ſolidity of bodies, and an inattention to the cauſe and mechaniſm of coheſion; which I mean to explain.

Admitting however, that motion were not the mechanical effect of a phyſical cauſe; but immediately given to ſuch inactive elements by the fiat of the creator, the conſequence, as Sir Iſaac Newton himſelf admits, is obvious; their motion would, by their mutual colliſions, be ſoon utterly deſtroyed.

The evident neceſſity of renewing it therefore, in order to keep up the ſyſtem, induced him to hint at the exiſtence of ſome active principle in that of a ſubtile æther, or elaſtic fluid, agreeably to the ſyſtem I have adopted.

Later philoſophers have deviſed various other expedients. Mac Laurin ſuppoſes there may be different kinds of moveable elements or matter poſſeſſed of different degrees of inactivity.

Dr. Knight conceives the whole ſyſtem of nature to be kept up by the mutual exertions of two active principles, ſubſiſting in his elements of attraction and repulſion.

Mr.

Mr. Colden, in his treatiſe on the principles of action in matter, ſuppoſes that there are at leaſt three kinds eſſentially different, a reſiſting matter, a moving matter, and an elaſtic matter, neither reſiſting nor moving.

Lord Kaims conceives that all matter is endowed with three powers or properties; firſt, that of continuing itſelf in motion; ſecondly, that of reſiſting a change from reſt to motion; and thirdly, that of gravitation; or, as he expreſſes it, a power to unite itſelf with every other piece of matter.

On the other hand Dr. Stewart profeſſor of natural philoſophy at Edinburgh, rejects any ſuppoſed activity in matter, or the moving object, conceiving it impoſſible to ſolve the phænomena of nature, on mechanical principles alone. The mutual repulſion and attraction which ſubſiſts between palpable ſolids and between the fluids in which ſuch ſolids ſwim (for ſo he terms it) he regards as the continual effects of thought and deſign in the firſt immaterial cauſe.

I leave metaphyſicians to treat of the immediate effects of immaterial cauſes. That the actions and reactions of the primary phyſical cauſes; in conſequence of which palpable bodies are generated and moved, and their ſituation and direction determined; that theſe I ſay, are the conſtant effects of an immaterial cauſe is moſt certain. But that the effects of this action or the modes of its exertion are not to be mechanically inveſtigated, I do preſume to deny.

To attempt indeed to give a reaſon why a power of reſiſtance univerſally prevails in all bodies. To give a reaſon for the formation of bodies ſpecifically different. To ſay why the ſame homogeneous reſiſting ſubſtance ſhould ſucceſſively enter into the compoſition of ſuch different bodies; why the ſame moving object is now the apparently inert and inſenſible ſtratum of a foſſile, now the moving and ſenſitive fibre of a vegetable, and now the active and ſenſible nerve of an animal. To ſay why the marrow that forms the brain of a gooſe may in a ſhort time form the brain of a philoſopher: all this, I ſay, muſt be imputed to the inſcrutinable direction of a ſuperior metaphyſical agent: to that omniſcient and omnipotent cauſe by whom we live, move, and have our being.

But

But to be aſſured that a reſiſting ſubſtance exiſts; that ſuch an univerſal principle or power of reaction really prevails; and to determine the conſtant and regular method in which the various revolutions, as well of the particular ſyſtems of bodies, as the general ſyſtem of nature, are mechanically performed; this is within our reach. Demonſtration and experiment, indeed, are confined within the narrow limits of ſenſe. Men of powerful organs and acute diſcernment may penetrate ſomething farther into the ſecrets of nature than others. Lyonet hath diſſected the caterpillar with nearly as much accuracy, as Albinus hath anatomized the human body. With the artificial aſſiſtance of teleſcopes and microſcopes, we can proceed ſtill a little farther. We can trace the motion of ſtars and planets otherwiſe inviſible; diſcover the almoſt inviſible animalculæ preying on the ſcarce-viſible inſect, and perceive how eaſy it is with a ſteady hand and a ſharp inſtrument to divide corpuſcles and to ſplit hairs. Theſe acquirements however are of little advantage. While perceptible magnitude is relative, numberleſs will be the ſyſtems of mechanical motion which we cannot explore. It will ever be impoſſible for us, for inſtance, to trace particularly the minuter parts of the mechaniſm of animals.

But though the complication of a multiplicity of moving objects in any ſyſtem, may perplex and baffle our capacity of inveſtigation, it does not therefore render their operation the leſs mechanical.

We may argue, therefore, as juſtly from analogy, as from actual experiment; if the premiſes on which the argument be founded are themſelves founded on experience.

I have ſhewn that, by a parity of reaſoning, we may as juſtly conclude the elements of bodies to be ſoft and elaſtic as hard and impenetrable. I have juſt now mentioned the ſeveral ſhifts to which, in the latter caſe, philoſophers are reduced to account for natural phænomena, either by the adoption of a variety of imaginary principles, or that unphiloſophical expedient of having immediate recourſe on every difficulty to the fiat of the creator.

If then, by admitting only this poſition, that the primary elements of bodies are elaſtic ſubſtances, originally diſpoſed by the will of the creator, in ſuch local relations

relations to each other, or are partially impelled in such different directions as to occasion the particular inequalities of resistance, necessary to produce the various motions intended; if from this simple position may be mathematically and mechanically deduced, not only the origin of motion, but the necessity of its known and established laws: if, not only the general laws of nature, but its principal phænomena, are hence to be inferred and explained; it is presumed the attempt to prove this practicable will be as acceptable to the philosophical world in general, as it is necessary to prepare my auditors for being convinced of the practicability of the perpetual motion in particular.

PART I.

On the Cauſe and Effects of Motion.

PRESUMING, on what has been ſaid, Gentlemen, that I have given ſome ſatisfactory idea of the nature and cauſe of motion in general; and taking it for granted that the ſimpleſt moving object is an elaſtic ſubſtance, whoſe dimenſions are determined by the reſiſtance of the like objects ſurrounding it; and not an impenetrable ſubſtance of a determinate form and abſolute dimenſions. I ſhall proceed to ſhew that motion is the natural and neceſſary conſequence of any inequality, by whatever means introduced, in the reciprocal reſiſtance of ſuch primary elements.

It may be previouſly neceſſary, however, to dwell a little on the mode of action of ſuch elements.

Elaſticity is ſuppoſed to be the effect of the modification of the parts of elaſtic ſubſtances. That of compound bodies indeed is ſo, but elaſticity in the ſimple elements is the primary cauſe, not a ſecondary effect, of motion.

And here we are led to make the neceſſary diſtinction between motion and action. Action is properly a phyſical term, motion a mechanical one.

We do indeed uſe the word action in mechanics, when we ſpeak of the application of mechanic powers; but the diſtinction between action and motion even here is evident, the motion of the parts of a machine about their common centre of gravity may be called its action. The change of place of the whole machine is its motion. The action even of a ſimple lever, is its turning on its fulcrum

fulcrum or point of reſt. Its motion would be the change of that fulcrum for another.

In circular motions, it is true, we commonly ſay, that a thing turns, or moves round its axis; but if the centre of gravity continue in the centre of motion, the place of the whole is not changed. It may be ſaid to act, if you will, but it cannot properly be ſaid to move.

Every ſimple motion muſt be recti-linear. Whatever moves muſt move in ſome one particular direction. It cannot move two ways at once. And though its direction may be changed every moment as in apparently circular motions, effected by the reſiſtance of ſurrounding obſtacles, every apparent circle is only a polygon of an imperceptible number of ſides: theſe ſides themſelves being deſcribed merely by motion, as I ſhall hereafter explain.

Mathematicians may amuſe themſelves with ſquaring the circle, and illuſtrating the doctrine of infinites by the ratios ſubſiſting between ſtrait lines and circles. There is no ſuch thing as a circle in phyſicks. Infinite ratios may exiſt in idea, but infinite quantities do not exiſt in nature.

And, though we might reaſon as truly about infinites as finites in geometry, we muſt exclude the former from natural philoſophy.

We may endeavour to imagine an infinity of ſpace and an eternity of duration, but we can perceive, and thence have a phyſical idea of, nothing but what is limited both as to place and time. Agreeably to this, it is very juſtly obſerved, by a late ingenious writer on the doctrine of fluctions, that quantities themſelves are not properly the objects of arithmetic or geometry; but only the ratios of quantities. *

Even the recti-linear extenſion of bodies, as I juſt now hinted, is a fluction. It is the mechanical effect of motion. The primary elements, though their reſiſtance be local, do not exert that reſiſtance in any one particular direction. Their

* Mr. Colden. See Enquiry into the principles of action in matter.

Their dimenſions are not limited by right lines. If it were, they could not preſerve their eſſential properties of number and identity, on which their very exiſtence as elements depends. They might, like the ſolid ſubſtance of the Newtonians, be diviſible ad infinitum; without loſing any eſſential property imputed to them.

A right line may be divided into any number of parts, each of thoſe parts would be as compleat and perfect a right line as the whole. But phyſical elements cannot be divided, without being deſtroyed, or diveſted of their reſiſtance; the quality eſſential to their exiſtence. Thus the diviſion of an elaſtic element would deſtroy its elaſticity. But diviſion and deſtruction are two things. Compounds may be cut to pieces and deſtroyed; but the wiſdom of Solomon could not divide one child between two mothers.

You will perhaps wonder, Gentlemen, by what line the extenſion of ſuch elements can be deſcribed; if no ſuch thing as a circle exiſts and right lines are the mere mechanical effect of motion.

It may be deſcribed by a line, which is neither circular nor recti-linear; one that cannot be divided into lines of the ſame kind, or divided at all without loſing its eſſential property, by ſuch diviſion. This is the ſpiral, a form which renders every body in nature capable of ſupporting it, elaſtic.

I ſay capable of ſupporting it, becauſe Mr. Colden ſays, it is to him inconceiveable why a ſpiral ſhape, or any ſhape or arrangement of the parts of any thing, ſhould give it any power which it had not before.

A ſpiral of lead, continues he, is as little elaſtic as a ſtrait line of lead.—True it is nearly ſo, but why? Becauſe lead is too ſoft and pliant to ſupport the form of a ſpiral.

Will he ſay a ſpiral of ſteel is no more elaſtic than a ſtrait line of ſteel? Has a watch ſpring wound up, no more elaſtic force than when it is run down?

The

The contrary is evident. Mr. Colden miſtakes the argument. It is not denied that the power of ſuſtaining the form of a ſpiral, lies in the component parts and compoſition of the ſteel, but it is not ſaid that a greater elaſticity is given to the ſteel itſelf, by its being formed into a ſpiral than it had before. No alteration is made in that arrangement of parts, in conſequence of which ſteel differs ſpecifically from lead, or any other metal.

If I take a piece of ſtrait wire and turn it three or four times round my finger, the ſteel is ſtill ſteel, and of the ſame temper as before; though it has acquired a ſpiral form. It is not the eſſential arrangement of the conſtituent parts of the ſteel, but the local arrangement of the parts of the ſtrait line that is affected.

It is this new arrangement of parts that generates a new being, whoſe mode of reſiſtance is peculiar to its form; and which, ſo long as that arrangement endures, will endure alſo, ſubſiſting and ceaſing with it.

An inattention to this circumſtance has occaſioned innumerable diſappointments to mechanicians, endeavouring to profit by the elaſticity of ſprings. Attentive to the general rule that ſprings unbend with the ſame force with which they are bent; and that their elaſtic force in general depends on the temper of the metal; they forget that the elaſticity of each particular ſpring depends immediately on its form, and that ſuch form is varied according as the ſpring is bent with a greater or leſs velocity. The compreſſion of the ſame piece of ſteel is therefore not always that of the ſame ſpring; nor will its dilatation have an equal effect, unleſs directly on the ſame body that compreſſes it.— This, and this only, ſeems to be the reaſon why profeſſor 'sGraveſande's clear demonſtration of the poſſibility of the perpetual motion, has not been long ſince confirmed by practice.

This error is the common effect of the popular notion of ſuppoſing the properties of things attached to ſome ſubſtratum or ſubſtance, diſtinct from thoſe properties.

The ſpecific powers of every palpable body in nature are the effect of the arrangement or motion of its conſtituent parts.

Even from the primary homogeneous elements exclusive, to the complicated body of the whole universe, the arrangement of the parts of one thing constitutes the essence of another. The very existence and different properties of fossiles, minerals, vegetables, brutes, all depend on, and are the immediate effect of, the arrangement of their specific corpuscles; in like manner dependent on that of the primary elements.

Thus it is not pretended that the different arrangement of the parts of any thing, can give new powers to that very thing: a different arrangement would constitute a new thing. If a watch spring and the steel of which it is composed were one and the same thing, there would be no occasion for watch-spring makers; the artist and his art would be useless.

The propriety of conceiving the action of the primary elements exerted spirally, is further evident from the reflection that, we thence avoid the contradiction of supposing one and the same influence exerted in two contrary directions at one and the same time; as would be the case in conceiving it exerted by emanation in strait lines on every side from a centre; whereas in the case presumed, the action of such element is one simple undivided action, the exertion of the influence of a single indivisible power; from the necessary effect of which, its reaction upon the contiguous elements, is nevertheless exerted on every side in recti-linear radii from its centre.

Thus when I compress a watch spring between my fingers and thumb, the resistance or reaction of the spring is exerted each way from the centre of the coil in the line of its diameter; but the action of the spring is exerted only in the single direction of the coil; the ends of it moving backwards and forwards in dilatation and contraction solely in that direction.

More depends on this individuality or identity of objects than may readily occur, both with respect to their action and motion. It is the property or horologary power of a clock or watch to divide the time, and point out the hours of night and day. Will any one doubt that such a thing as a clock exists? or that its essential property is the mechanical effect of its arrangement of parts?

Separate

Separate thoſe parts from each other or give them a different arrangement; they have no longer the ſame property. The clock is annihilated, though every wheel and pinion of it remain, uninjured, whole and entire. I might purſue the alluſion through all nature; but ſhall confine myſelf to the immediate object of this lecture.

The diſcovery of a perpetual motion, ſays De la Hire, would be to diſcover a body at once heavier and lighter than itſelf. But this is not a fair ſtate of the queſtion. It is not neceſſary that all the parts of a perpetually-moving machine ſhould be attached to, and inſeparable from each other. Which they muſt be, to conſtitute one gravitating body of a determinate weight.

In animals the blood circulates freely through their veins and arteries in all poſitions of the containing veſſels; every globule of blood in the body has a centre of gravity of its own, independent of the centre of gravity of the whole body. A conſiderable quantity of blood may be taken away, and, thence diminiſh the weight of the body, without putting a ſtop to its motion, or diminiſhing its activity; which, if the perpetual motion were on this account impracticable, could not be. Indeed were ſuch the caſe, on this or any other account, the blood in a man's body, when ſtanding erect, would fall into the legs and feet, nor could the wiſdom of the wiſeſt and the ſtrength of the ſtrongeſt man united, raiſe it up again. This circulation indeed is generally imputed to the dilatation and contraction of the heart. But to what is the motion of the heart imputed? Neither to the wit of the wiſe, nor the will of the wilful.

It is ſhewn by Dr. Keil that if the circulation of the blood were once ſtopped, not all the muſcular force of the heart would put it again in motion.

It is, in fact, the circulation of the blood that keeps up the motion of the heart, not the heart the circulation of the blood. The incumbent preſſure of the atmoſphere on the blood veſſels cannot poſſibly be the cauſe, as ſome ſuppoſe, of the riſe of the blood in the veins. A partial compreſſion indeed might cauſe a partial ſtagnation of the blood, but an undequaque preſſure can never be the cauſe of its general circulation. Beſides, Mr. Boyle hath ſhewn that the heart of a frog beats as regularly, and as ſtrongly, in vacuo, as in the open air.—

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The circulation of the blood, and, in conſequence of that, all the animal functions, are, and muſt be, kept up by ſome mechaniſm in the body by means of which the blood riſes, either in ſmaller globules or by ſome other means, ſo as to gain a force on gravity, to repair the motion diſſipated by its friction againſt the containing veſſels. And that ſuch force is to be ſo gained, I ſhall hereafter prove by the moſt inconteſtible experiment.

At preſent I ſhall only beg leave to exhibit a very ſimple one univerſally conceived to be as much an impoſſibility as the perpetuol motion itſelf; by which however that impoſſibility as well as the abſurdity exploded by De la Hire, appears to be really a fact. It is notorious that the preſſure of a ſmall quantity of a fluid is the ſame againſt the ſides of the containing veſſel as that of the greateſt quantity at equal depths; the preſſure of fluids following ſimply the proportion of their depth. Hence if the area of a veſſel be ſmall and its depth great, a very ſmall weight of water will preſs againſt the bottom with prodigious force. Nay, by means of a veſſel of different areas, at different heights, as a barrel with a perpendicular pipe carried through its head: if the head of the barrel be moveable and yet water-tight, a little water, poured into the pipe, will actually raiſe up a vaſt weight laid upon the head of the barrel. Here a ſmall quantity of a fluid hath comparatively as much weight or gravitating force as a greater. Now I ſhall ſhew that this is not only the caſe with different quantities of a fluid; but that the ſame individual ſolid will, in like circumſtances, appear to have a leſs and a greater weight than itſelf.

I muſt firſt however beg leave to obſerve, that there are two methods of eſtimating the weight of bodies. One is by the common ballance, by which their comparative weight only is determined; being weighed one againſt another or againſt ſome third body, which is made the common ſtandard of compariſon between both.

The other is by the elaſticity of ſprings, which ſuſtain weights equal to their elaſtic force. This determines the real weight: one body not deſcending as in the ballance, in proportion as another riſes; but deſcending in proportion as the ſpring is bent; the elaſtic force of the ſpring being oppoſed to the gravitating force of the body. Hence it appears evidently impoſſible that the perpendicular

dicular preſſure of the ſame body, ſhould not equally compreſs the ſame ſpring: the elaſtic force of the ſpring being the meaſure of the gravitating force of the body. Yet ſee, Gentlemen, here is a ring of tempered ſteel; which, being placed within the edges of this box, is compreſſed by means of this fulcrum.* The fulcrum itſelf is nothing more than a ſtrait piece of braſs, projecting horizontally from two parallel perpendicular ſliders, on the top of which is placed the weight. Till the ſpring be placed under the fulcrum, the latter will ſupport no weight at all; but both the ſliders may be moved up and down, together with the fulcrum, with the ſame eaſe; A proof that when the ſpring is placed under the fulcrum, no oppoſition is made from any other cauſe to either. And yet when the weight is laid on the different ſliders, the ſpring will ſupport it on the top of one, on being bent very little; whereas, if laid on the other, the ſpring will be bent very conſiderably. If then the elaſtic force of the ſpring, be the meaſure of the weight of the body, we have here a piece of lead apparently heavier and lighter than itſelf. The proportion in this inſtance is juſt as two to one, but it might be encreaſed as an hundred to one.

You ſeem ſurprized, Gentlemen, but there is no abſurdity, no contradiction in all this. The weight of bodies, as eſtimated by the ballance, is as before obſerved merely comparative; their weight as eſtimated by the reſiſtance of a ſpring is real; and there is no more reaſon why the real and comparative weight of bodies ſhould be equal, than why their ſpecific weights ſhould be ſo too, which are univerſally admitted to differ. In the preſent caſe, when the weight is laid on one ſlider, the ſpring acts againſt its real weight; when on the other, againſt its comparative weight. The matter, if you will, may be called paradoxical; but ſo was for a long time the equality between the comparative weight of a heavy body at the end of a ſhort lever and a light one at the end of a long lever.

This equilibrium between bodies ſo ſituated, that in other circumſtances are of different weights, was for ages looked upon as a kind of miracle in mecha-

* See plate 1. fig. I.

nics; though, now we are better acquainted with the laws of gravitation and motion, it would be miraculous if it were otherwiſe.

It is every day experienced, with the common ſteel-yard, that one pound at the end of ten inches from the centre of ſuſpenſion, is comparatively of equal weight to ten pound at the end of one inch.

The difference between the real and comparative weight or gravitating force of a body, will appear yet more plainly, if we ſuppoſe that the body, inſtead of barely preſſing the ſpring, ſhould fall from any height perpendicularly down upon it. Let us ſuppoſe, for inſtance, a weight of four pound to fall from the height of four feet. As the ſpace deſcribed by falling bodies is as the ſquare of their velocity, it will in falling four feet acquire two degrees of velocity, and of courſe being four pound bend the ſpring with eight degrees of force; which is in this caſe the real momentum of the motion acquired by its gravitating force in falling that diſtance.

Now it is well known that, it would require exactly the ſame force to throw the ſame body up again in the ſame time to the ſame height. But it is as well known that the weight of one pound, and ever ſo little more, at the end of a ballance beam of ſixteen feet, would weigh up four pound to the height of four feet, from which it fell.—It is equally as well known and certain that, if one pound be freely let fall ſixteen feet, it will acquire but four degrees of velocity, and of courſe have acquired but four degrees of momentum by its gravitating force; which is but half the force of the greater weight; which nevertheleſs it counterballances both in motion and at reſt: the effects of the comparative gravity therefore of the two weights, is in this caſe equal, while thoſe of their real gravity differ as two to one.

It is on the mechanical advantages to be taken of this difference between the real and relative weight of bodies that the perpetual motion is founded. It is in fact nothing more than the weighing a heavy body up by a ſmall comparative weight, and letting it fall with its own real weight: while, on the other hand, the light body riſes with its real weight and falls with its comparative weight:

by

by which means a force may be gained on gravity, at every riſe and fall, proportional to the difference between the real weight of both.

To explain more fully the difference between the elaſticity and weight of bodies, on which both the theory and practice of all mechanic powers depend; it will be neceſſary to recur to the action of the primary elements; whoſe elaſticity I have endeavoured to illuſtrate; by imputing their action to the exertion of a power in a ſpiral form.

The ſpiral indeed is uſually conſidered in phyſicks, like the circle, as a compoſition of imperceptibly ſmall right lines. But the difference is obvious. Let us ſuppoſe for inſtance, the periphery of a circle to have real exiſtence, and to be diviſible; every divided ſegment of that circle would deſcribe the ſame curve as the whole: that is, it would have the ſame property or bear the ſame geometrical relation to a right line, of the ſame length, as the whole circle would to a right line of its whole length. It is otherwiſe with the ſpiral.

For, ſuppoſe it diviſible into parts, as in the caſe of the periphery of a circle, every part of it would be a different kind of curve. They would not each bear the ſame geometrical relation to a right line proportional to their length.

A ſpiral indeed may with greater propriety be called the generative part of a line, than a line itſelf: as the phyſical elements may be, in like manner, more properly called extending than extended; the elements of extenſion rather than extended elements; as will appear from conceiving the diſtance between any two mathematical points deſcribed by ſpiral motion. The moving object would not, in any part of that diſtance, move in the line of direction between thoſe two points. But, if they lay eaſt and weſt, it would move in all directions of the compaſs, in moving ever ſo little eaſtward or weſtward in that line. If the line were eaſtward it would move weſtward firſt, as well as northward and Southward; and, if weſtward vice verſâ; becauſe it muſt deſcribe a circle round the point, from which it moves, before it arrives at the point to which it is moving. Hence it is plain that each ſuch element, circumſcribing its centre on all ſides, will conſtitute an indiviſible, incommenſurable, elaſtic, ſpherical form; whoſe diameter, if I may ſo call it, will be leſs than any phyſical right line

line whatever. Becauſe a right line being diviſible, it muſt of neceſſity comprehend at leaſt three mathematical points, a beginning, a middle and end. But a primary element deſcribing only the neceſſary diſtance between two, muſt of neceſſity be ſtill leſs.

Every actual motion, is, as I have ſaid, recti-linear, though not every action. The undequaque reſiſtance, or elaſticity of matter, is the effect of its ſpiral action; its change of place in any particular direction is the effect of ſome partial reaction, or impulſe and is its motion.

An elementary power may act ſpirally from a point, though it cannot move, or change its place, but in a right line. Its dimenſions alſo, in conſequence of ſuch actions being exerted uniformly round its centre, would aſſume a ſpherical form; and, though its contraction and dilatation ſhould be effected, as in the caſe of a watch ſpring, ſpirally, and not in a diverſity of right lines, emaning in different directions from ſuch centre; yet the reaction of ſuch elements, or the reſiſtance they would make to each other, would be exerted in ſuch right lines from and to the centres of each.

Such elements alſo might thus act and react, and yet be perfectly indifferent either to reſt or motion. Their mere change of place in any particular direction, would not at all interfere with their internal action; or their mutual reactions with the action of each other. At the ſame time that their undequaque reſiſtance, or reaction, would be ſtill the ſame whether in motion or at reſt; as we find indeed to be univerſally the caſe with all bodies.

Again, every ſuch power might ſo act independently of any other; ſo that, as we can form no idea of the exiſtence of a power that does not act, we hence avoid the abſurdity of admitting paſſive powers, and negative properties in phyſicks.

The propriety of the diſtinction between action and motion appears hence alſo, more evident; in that each ſingle element might act of itſelf, by virtue of its inherent power or principle of activity; whereas it is impoſſible that motion can be generated among ſimple elements, without a partial inequality in the

reactions

reactions of two or more ſuch elements; or propagated among compound bodies without the equal and contrary motion of at leaſt two ſuch bodies.

Mr. Locke, indeed, calls motion, action; and ſays there are but two ſpecies of action; motion and thinking; and talks of the poſſibility of a capacity of thinking being annexed to ſimple, inert matter.

Dr. Stewart, on the other hand, though he abſolutely rejects, on the authority of Clarke and Wollaſton, the latter notion, as well as the more plauſible opinion of Hobbes, that a kind of obſcure ſenſe or perception is inherent in all matter; yet conceives, that a power of beginning motion ſeems neceſſarily to infer a power of thinking. At the ſame time, however, he admits that, for ought we know, there may exiſt ſome ſpecies of thinking beings, deſtitute of the power of motion altogether. Oyſters, in particular he obſerves, have very little of this power. But might we not aſk this learned profeſſor, how he knows that they have the power of thinking in a greater degree than that of motion? For my own part, I muſt own, I have no great opinion of the intellectual abilities of an oyſter: nay, though it were the moſt ſagacious of a whole barrel; and that the moſt ſenſible that ever came from Colcheſter. I could almoſt as readily impute ingenuity to vegetables and foſſiles; to the ſenſitive plant and the loadſtone; as meditation to muſcles or cogitabundity to cockles, periwinkles and rock oyſters.

Neither Mr. Locke nor Dr. Stewart, did, in this particular, diſtinguiſh with their uſual accuracy. It is foreign to our purpoſe, or it would be eaſy to prove that, whether thinking be properly termed an action or not, it cannot be the action of a ſimple uncompounded ſubſtance; and ſtill leſs is it the immediate cauſe of motion. We are led into this error from our very naturally attributing intelligence to the great firſt cauſe. But, though we are obliged to make uſe of the ſame terms, to expreſs wiſdom and deſign in the deity as in ourſelves, inteſligence divine and human muſt differ as much as cauſe and effect. For high as the heavens are above the earth, are his thoughts above our thoughts; his ways above our ways. One eſſential difference at leaſt, is evident in the thoughts of the creature and the creator. The deſign of a created being determines only the mode in which it will exert the phyſical power, whether of

elaſticity or weight, that it is poſſeſſed of in common with inanimate bodies of the ſame quantity of both. But the deſign of the creator carries with it the immediate power of execution to any degree. The deſign of the creator is his fiat, his fiat the execution of his will, whatever it be, it is no ſooner deſigned than it is done. The creature, however ingenious, may form projects and deſigns innumerable beyond his powers of execution. The human imagination may form ideas; but mere ideas are all it can form. The will of the deity is omnipotent it hath made a material univerſe of immenſe momentum and moves gravitating worlds through elaſtic media with amazing velocity; the will of man cannot create a material atom, or give motion even to the goſſamer that idles in the wanton ſummer air. So weak humanity!

Lord Kaims makes no diſtinction between action and motion; but conſiders motion as a continued action; and controverts the capacity of inert matter to preſerve a motion once impreſſed on it. But in illuſtrating this, he contradicts known experience. When the cauſe of motion ceaſes, ſays he, we ſeek no other cauſe for the ceaſing of the motion. Walking or running requires a continued exertion of power. It requires no exertion of power to put an end to theſe motions.

Dr. Stewart, on the contrary, oppoſes this doctrine; and very juſtly defends the continuation of motion, on the Newtonian principle of the vis inertiæ, or the indifference of matter to motion and reſt. But a man who ſhould walk, or run with any conſiderable degree of velocity, particularly down-hill, will want no authority to be convinced that it does require a conſiderable effort to put a ſtop to his motion. He does not ſtop the moment he ceaſes to exert his power to move forward; but muſt exert a contrary power and that for ſome time before he will ceaſe to move. If during that time he throws his legs forward, it is only to keep himſelf upright, and prevent his falling on his noſe; not to carry the center of gravity of his body forward, but rather to throw it backward.

Motion, on the other hand, ſays the laſt mentioned philoſopher is not action; but the effect of an action; and pertinently aſks, Why may not an active being communicate motion to matter, without moving itſelf? Judiciouſly obſerving,

ing, that, whether the agent itſelf moves or not, it muſt have a power of acting, previous to all motion; otherwiſe it would be impoſſible for matter, or any other being, to begin motion of itſelf.

I have already anſwered his queſtion, by ſhewing the impoſſibility of communicating motion to ſolid matter by mere impulſe. And as to his obſervation, we may, in our turn, obſerve, that no finite created being, whether ſolid or fluid, active or inactive, animate or inanimate, can begin to move of itſelf.

Motion, as he truly aſſerts, is the effect of action; but it is only a ſecondary effect. The motion of any individual is not the direct and ſole effect of the action of that individual. Two active elements may, by their mutual reſiſtance or reaction, put each other in motion; but the reaction of the one, is reciprocally and jointly the cauſe of the motion of the other; and not the ſimple action of either. Nor is this all. There muſt be ſome inequality in their mutual reſiſtance, ariſing either from the inequality of their own denſity, or that of the ambient medium; otherwiſe neither would move.

The fore-finger of my right hand, preſſing againſt that of my left, will put it in motion; provided there be any inequality in their mutual preſſure, but if they preſs each other equally; that is, if their reactions be equal; being in oppoſite directions, no motion of either enſues, with whatſoever force they may preſs againſt each other: Motion being ever generated in the direction of the leaſt reſiſtance.

Motion therefore is not the direct effect of the ſimple action of any ſingle individual; or even the equal reactions of two; but of a partial and temporary inequality in the reſiſtance or reaction of two or more.

This will appear ſtill more clearly, on adverting to the propagation of motion among palpable bodies. Theſe are uſually diſtinguiſhed, on this occaſion, into animate and inanimate; the animate body being ſuppoſed capable, by virtue of its conſciouſneſs or power of thinking, to begin motion of itſelf, and the inanimate only of continuing the motion given it.

But

But though I impute that phyſical action, which is the primary generative cauſe of motion, to the conſtant exertion of an univerſal, metaphyſical cauſe; to the great creator and governor of the univerſe; though I do not join with Hobbes or Leibnitz, in imputing conſciouſneſs or intelligence to monades or phyſical atoms, it does not by any means appear to me than even animated bodies are capable of originally generating motion in and of themſelves. Indeed we diſtinguiſh an animate from an inanimate body, only by its apparently-voluntary or involuntary motion. If all its motions are the ſimple and obvious effect of ſome other body moving it, we ſay it is inanimate and its motion is called involuntary. If they are more complicated, and we do not ſee into the motives of its change of place, we ſay it is animated; its motion is voluntary, and we impute to it a capacity of thinking. Dr. Hill tells us, in ſpeaking of microſcopical obſervations, and I dare ſay, he tells us truly, that certain late philoſophers of the royal ſociety, hence miſtook the ſeeds of a certain plant for living inſects. On the ſame grounds it was, that the Mexicans miſtook the Spaniſh ſhips when they firſt approached their coaſt, for huge fiſh or ſea-monſters riſing out of the ocean; as for the like reaſon the Indian-of-the-lakes took the firſt watch, he ſaw, for a demon or the familiar of a conjurer.

But the motion of a body, as I have before hinted, is not immechanical, merely becauſe we cannot explore its mechaniſm. Even voluntary motion itſelf is imputed to ſome motive. A man does not move this way or that without ſome inducing cauſe; and, whether it be metaphyſical and mental, or mechanical and material, is determined only from its apparent modus operandi: by its producing its effect by means of the internal organs of conception and reflection, or the external organs of ſenſation and motion. The one may be anatomized; the other eludes diſſection; but we neither know nor can know that there is any eſſential difference in their mode of action.

Nothing however is more certain than that animals do not move merely becauſe they have a capacity of feeling, thinking, and willing; though perhaps they may feel, think and will, for the ſame reaſon that they are capacitated to move. Even Dr. Stewart admits that, though a power of beginning motion ſeems neceſſarily to infer a power of thinking, we cannot inverſely affirm that a power of thinking muſt infer a power of beginning motion.

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The anatomiſts agree that, in the voluntary motion of the limbs of animals, the influence of their will ſerves only to turn the ſcale, if I may ſo term it, between two mechanic powers, vibrating in equilibrio; as the muſcles, ſerving for voluntary motion, have each its antagoniſt; and would be in a ſtate of perpetual contraction, notwithſtanding the ſtrongeſt exertion of the will, were it not for the equipollent libration of theſe antagoniſts.

But let thought or deſign proceed from what it may; whether it be, or not, the action of any particular ſubſtance; it is not the generative cauſe of motion, any more than motion, as Colden and others have conceived, is an inherent quality in any thing. The motion of a thing is a temporary and adventitious circumſtance, and not a mode of exiſtence or conſtant eſſential property of any ſimple being. Even as to palpable bodies, 'tis plain, they may be now at motion and now at reſt, and ſometimes in a ſtate between both; as they are in the propagation and communication of motion by percuſſion; during which interval, the direction and velocity of the motion is generated by the percuſſion and repercuſſion of their component parts. For, however uncommon may be the obſervation, that bodies are ſometimes neither in a ſtate of motion nor reſt, but between both; it is very true, conſidering them, as they are, compounds and individuals at the ſame time. Were they perfectly ſolid and ſimple indeed, they could not: they muſt be in motion or at reſt; but being compounded, there muſt be ſome time, however ſmall, between the moment in which their parts are ſtruck with a certain velocity on one ſide, and the motion of their parts with a different velocity on the other; during this interval the body is neither wholly in motion nor wholly at reſt: an interval very perceptible in the colliſion of compound elaſtic bodies; and, as I have ſaid, we know not that bodies perfectly hard and unelaſtic exiſt in nature. Admitting even the exiſtence of ſuch bodies, motion could be no more communicated from one to another, in the manner it is, by percuſſion, than, as I have before ſhewn, they could originally receive it by ſimple impulſe. For, being indifferent equally to motion and reſt, the ſolid at reſt, impelled by another in motion, would either change its place, with infinite velocity, or move forward in the ſame direction with the ſame velocity.—But this is not the caſe. The momentum of the motion is divided between the two bodies; which if equal, move on after colliſion with only half the velocity of the firſt mover. This diviſion,

therefore, is effected by the ſucceſſive action and reaction of the parts of the two bodies; by which means thoſe of one are impeded in their motion, as much as thoſe of the other are impelled to move.

It is admitted, indeed, that the action and reaction of the ſpecific parts of palpable bodies conſiſts of actual motion. It may therefore be pertinently aſked, how theſe, if once repelled, are brought to move forward again in the direction of the impelling body? I anſwer, by the repulſion of the medium in which they exiſt, and by virtue of which they cohere.—For it is to be obſerved that the gravity or weight of bodies, though always proportional to their quantity of reſiſtance, is not proportional to their elaſticity or the number of primary elaſtic elements contained within their dimenſions. On the contrary, the heavieſt and hardeſt body in nature, will contain the feweſt elaſtic particles in its compoſition: ſo that in the centre of a ſecondary element, generated by motion, the hardeſt, heavieſt and moſt impenetrable of all bodies, there would be a vacuum almoſt as perfect as that ſuppoſed by the Newtonians, in mere ſpace.

For I ſhall prove mechanically to be true, what Sir Iſaac Newton ſuggeſted that the æther or the elaſtic medium is the denſeſt, where there are the feweſt and lighteſt palpable ſolids.

But this I ſhall explain more fully, when I come to ſhew, why the parts of bodies gravitate and cohere; and how the reſiſtance, which ariſes merely from elaſticity or action in the primary elements, is ſupplied by motion in the ſecondary ones.—But to return—Though a contender for the perpetual motion, I am ſo far from being an advocate for what may be ſtrictly called ſelf-motion, that I do affirm no finite created being whatever is capable of ſuch ſelf-motion. Even the moſt nimble animal in the creation, exert what force it will, cannot move an inch without the aſſiſtance of ſome other body; which in its turn muſt be moved by it equally in a contrary direction.

This is a certain and neceſſary conſequence of the mechanical principle of action and reaction, prevailing throughout all nature: The univerſal equality of this action and reaction in oppoſite directions, being itſelf the neceſſary conſequence of bodies being compoſed of, and moving in, an elaſtic medium.

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This is a critical point, Gentlemen; and, I own, I do not expect you will readily give up your privilege, of ſelf-motion; or condeſcend to think yourſelves obliged to ſtocks and ſtones for their aſſiſtance in moving yourſelves. And yet, humiliating as may be the reflection, man, in his preſent ſtate is ſo incumbered with matter, and ſo dependent on the objects about him, that he cannot ſtir a foot without them. What, you will ſay, cannot we, impatient of ſuch diſcourſe, riſe up and go about our buſineſs at pleaſure? Doubtleſs, Gentlemen, the will is free and your diſguſt will be a ſufficient motive of action: but you cannot, by any action of your own, put yourſelves in motion, without putting, at the ſame time, ſome other body in equal motion a contrary way; whoſe reaction muſt jointly determine the way you are to go. So far from being capable of changing your place, and going out of the room; you cannot even change your poſture, and riſe from your ſeats, without the aſſiſtance of the very chairs on which you ſit. Have you the patience to permit me farther to explain myſelf?—I am obliged to you, Gentlemen, I ſee you are not ſufficiently diſguſted. Your chairs do not move yon. I find, I may go on.

Profeſſor Stewart, whom I have ſo often quoted, talks, indeed, on a ſimilar occaſion, of a man's giving himſelf a puſh, when he wants to go forward; and tells us that the common account of the progreſſive motion of animals, as given by Borelli, and admitted by moſt other authors, is too conciſe, if not falſe; videlicet, that in walking, flying, or ſwimming, the animal acts upon the ground, air, or water, in one direction; and that the reaction of the medium carries the animal forward, in another direction.

This theory, adopted by Sir Iſaac Newton and almoſt all experimental philoſophers, is controverted by the profeſſor; who tells us, on the other hand, that the only immediate cauſe of the motion, is the active force of the animal; which preſſes the medium one way and its own body another. But were this the caſe, it is evident, on the very face of the propoſition, that the ſame body might actively tend to one ſide, and alſo actively tend to the other, at the ſame time.—This the profeſſor himſelf allows to be a contradiction in terms. A man indeed may, with one hand, preſs againſt one object in one direction; and with the other againſt another in a contrary direction, and may move both: but,

but, if their reſiſtance to his preſſure be equal, he himſelf will not move, or be moved at all. And, if unequal, he would be moved, like every other body, in the direction of leaſt reſiſtance. If a man could move, or change his place, merely of himſelf, he could of himſelf put an end to any motion into which he might be put. But this we find impoſſible. A man hurried along by a force ſuperior to his own, cannot ſtop himſelf, till he meets with ſome obſtacle of greater reſiſtance; a ſtone, poſt, or a brick-wall, for inſtance; by whoſe friendly aid he might be ſtopped.

A philoſopher falling from the top of a houſe, with all his ſagacity, reſolution and activity, cannot ſtop himſelf, at leaſt now the ſign irons are taken away, till he comes to the ground.—I have indeed heard of a man, who once undertook to jump off the monument, for a wager; but when half way down, found he could not do it; ſlunk up again and yielded the wager loſt.

You may ſmile, Gentlemen, but unleſs any of you will avouch the truth of this ſtory, I cannot admit that, without aſſiſtance, any of you can actually move yourſelves. It is pretty obvious, in the caſe of leaping, dancing and jumping, that we do not altogether move ourſelves. To inſtance only the ſimple caſe of the tight rope: let the dancer cut the ſame capers if he can, by preſſing his feet in the ſame manner and with the ſame force againſt an inflexible rod of iron. Would he be able, think you, to ſpring ſo high? And yet, if our motion be the immediate and ſole effect of our own activity; Why not?

It may be imagined that when a man holds out his arm at length, that it is done merely by a ſimple and ſingle act of volition.—Not ſo.— It is raiſed, perhaps by a ſingle act of the will, determining the direction of leaſt reſiſtance among the equilibrating muſcles; but it muſt be ſuſtained by repeated acts of volition; that keep the ſuſtaining muſcles and their antagoniſts in conſtant vibration; or it would deſcend in the direction of gravity.

Hence we ſee that animals cannot ſupport even the weight of their own limbs, for a length of time, without fatigue and wearineſs. And hence the reaſon and evident uſe of reſt and ſleep; to give the fibres of the muſcles

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time to recover their elaſticity, when their tone is too much relaxed by vigilance and labour. All this is merely mechanical.

So very mechanical, indeed, is the whole buſineſs of animal motion, that I ſhould not wonder if ſome ingenious artiſt, verſed in the practical expedients of machinery, ſhould, under the direction of a Cox, or a Pinchbeck, contrive an inanimate automaton, that might be led about the room by a boy, as a blind beggar is about the ſtreets by a dog and a ſtring.

That ſceptical ſmile, Gentlemen, carries with it, a Credat Judæus Apella. And yet it is certain no greater exertion of animal power would be required, than juſt to incline the centre of the automaton's gravity in the line of direction, and at the ſame time to throw one leg forward to keep it from falling, and preſs the other downwards to raiſe the centre of gravity; and this the weight of the boy might be able to perform by pulling at the end of a ſtring. Nay, we often ſee live animals ſo pulled along even againſt their inclination; but their centre of gravity being drawn forward, they are obliged to move their legs or fall down; in the mean while they are dragged on by the action of the body pulling them, as much as a cart is by the horſes; the motion of the legs in one caſe and the wheels in the other, ſerving only to keep the centre of gravity from falling.

Let us ſuppoſe, Gentlemen, that, inſtead of ſitting upon common chairs, the weight of your bodies were ſuſtained by elaſtic ſprings: if, in order to riſe, you were to preſs with the ſedentary muſcles againſt ſuch ſprings, as forcibly as you would againſt a chair, you would not only be thrown up into an erect poſture, but would be tumbled forward on your faces upon the carpet.

But it may be neceſſary to illuſtrate this matter ſtill farther; as more depends on it, reſpecting the perpetuity of communicated motion, than may at firſt be imagined.

Lord Kaims, who too readily admits, on the fallacious evidence of a ſingle ſenſe, that an animal may move itſelf; argues, in order to prove it, againſt the univerſal equality of action and reaction, and objects to Sir Iſaac Newton's il-

luſtration of it: ſaying we ſhould make a diſtinction between moveable and immoveable obſtacles. But no ſuch diſtinction really exiſts. Motion, as it is not the eſſential property, or mode of exiſtance, of any ſimple ſubſtance; ſo neither is it the durable ſtate of any ſuch ſubſtance. The object, indeed, which is reſiſted on all ſides, is, ſo long as it is ſo equally reſiſted, at reſt. But all phyſical obſtacles are not only moveable, but in actual motion: their reſt is only relative. Bodies equally reſiſted on all ſides, or thoſe moving with the ſame velocity the ſame way, are indeed at reſt, with reſpect to each other: though with reſpect to another combination or ſyſtem of bodies, they may be in motion with prodigious velocity. With regard to each other, Gentlemen, and the apparently immoveable objects about you; ſo long as you remain in any particular place, you are relatively at reſt; and yet nothing is more certain than that the room itſelf, with all that are in it, is moved by the diurnal revolution of the earth many thouſand miles in a minute.

This every body knows, and yet almoſt every body inadvertently concludes, that men are at reſt, when they are not put in motion by themſelves, or ſome other animated being: the obſtacle, indeed, is called immoveable when, being apparently at reſt, its quantity of matter is prodigiouſly great, in proportion to that by which it is puſhed, or pulled, drawn or impelled: becauſe in that caſe, its velocity is comparatively ſo ſlow as to be imperceptible; the force of the action and reaction being in all caſes equal; which it would not be, if the velocity of the motion were not always reciprocally as the quantity of the moving matter.

Hence the famous poſition, drawn as a corollary from that of the vis inertiæ, or indifference of matter to motion and reſt; viz. that the leg of a fly moves the whole globe of the earth.

This inſtance, however, has the common fault of familiar illuſtrations. It does not fully apply; as it would do, if the globe of the earth were a perfectly ſolid body. For an obſtacle may alſo be called immoveable (as it is to all intents and purpoſes equally ſo reſpecting the moving body) when, being of the ſame weight, it meets it with the ſame velocity in a contrary direction.

It ſtops the body as much in one caſe as the other, and is therefore an equal obſtacle to its motion. The putting a ſtop to any motion, by moving in an oppoſite direction before colliſion, requires the ſame force and is in effect the ſame thing, as moving a contrary way after colliſion. The various motions therefore of the component parts of the earth in a contrary direction, prevent the fly's actually moving the whole.

It has been often remarked, by writers on this ſubject, that the animate body differs from the inanimate, with reſpect to motion; in that the thinking being can determine the quantity of its motion, on any occaſion. But this is true only to a certain degree. An animal indeed may exert his power in various degrees, within that of its own weight, and the weight it is capable of ſuſtaining; but no farther. It might divide and diverſify the direction or tendency of that power; but it cannot encreaſe its momentum, or exert as much more force on any occaſion as it will. When we ſee a waggoner belabouring a poor horſe, to make him draw a weight, which he is incapable of ſtirring: The Brute (I don't mean the horſe) ſeems to think, with ſuch philoſophers, that the animal can exert as much power as he pleaſes. But he finds the contrary, while the willing beaſt is cruelly loaden with ſtripes, for ſuppoſed ſtubbornneſs or ſloth; when his only fault is the want of food to fill his belly, by which he might acquire a little more fleſh on his back. Animal reſolution is not a mechanic power. An animal without weight, how great ſoever its good will, would not be able to lift, or draw a ſingle feather.

The objections indeed which have been ſtarted to the univerſal equality between the action and reaction of bodies, have taken their riſe chiefly from the defective manner in which it has been illuſtrated.

Thus it has been ſaid that, when a horſe draws along a ſtone, the ſtone draws the horſe backward with a force equal to that with which the horſe draws the ſtone forwards.

To this it has been objected, * that "nothing more can be meant by it than that the horſe loſes as much force as the ſtone gains; and that with reſpect to the horſe the effect is the ſame as if there was no ſtone tied behind him; but that

* By Dr. Stewart. See Edinburg Eſſays

that he was puſhed back with a force equal to that acquired by the ſtone. The active force of the horſe's limbs preſſes forwards, it is ſaid, both the horſe and the ſtone; what is called the reaction of the ſtone is not equal to the whole force exerted by the horſe; for then indeed there could be no progreſſion, it is only equal to what is impreſſed upon the ſtone."

But the truth is that neither the illuſtration nor the objection are applicable to the point. As to the firſt, in pulling or drawing, we do not directly act, or impreſs any motion, on the thing pulled or drawn, as in puſhing or thruſting. In the caſe of the horſe and the ſtone; the horſe acts only againſt the ground; and even in that not in a direction immediately contrary to that in which he moves. As to the ſtone, it is entirely paſſive, and though it cannot help following the horſe to which it is faſtened, does not exert any action affecting its motion in any direction whatever. That the ſeveral parts of the ground, the horſe, the rope, and the ſtone, do reciprocally react on each other during the generation of the motion, I grant; for hence are its direction and velocity determined, but when the rope is ſtretched to its utmoſt degree of tenſion, both the horſe and ſtone move together as one body. The horſe would certainly move faſter without the ſtone, as the ſtone would lie at reſt without the horſe; but for no other reaſon than that the ſame force of reaction could not move a maſs equal to both, with the ſame velocity as it would move either.

In like manner, it is ſaid, that when a perſon in a boat pulls a rope, which is faſtened to the ſhore; the man acts upon the ſhore in one direction, and that the ſhore, by its reaction in the oppoſite direction, pulls the man and boat towards it.

To this it is alſo, in the ſame manner, objected that it is evidently the force of the man extending himſelf that draws the ſhore, with his hands, one way, and at the ſame time puſhes the veſſel with equal force, with his feet, the oppoſite way.

In reply to this it may be ſaid that, though a man by extending himſelf, as profeſſor Stewart terms it, might puſh bodies in different directions from him, it can only be by contracting himſelf or by moving in a contrary direction he can draw any thing toward him. He thinks no man can ſeriouſly maintain "that

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the ſhore can draw the man in the boat," yet tells us that the man in the boat really draws the ſhore. But the ſhore is certainly as much at reſt, as it is inactive. The truth is, that drawing and pulling are popular and unphiloſophical terms; they expreſs rather the concomitant effect, than the cauſe of motion; which is originally generated by direct repulſion and not by indirect attraction. Nothing can act where it is not: the man is at a diſtance from the ſhore and neither of them acts upon the other. When the man pulls the rope indeed, the ſhore, the man, and the boat, are all one body: and neither act nor react on each other. The immediate cauſe of the motion of the boat, is the action of the boat on the water, and the reaction of the water againſt the boat; the inequality of which determines the boat to move on the ſide of leaſt reſiſtance. This is plain, for a man with the ſtrength of Sampſon might not be able with his hands to draw either the ſhore to him, or with his feet to puſh the boat to the ſhore, againſt an oppoſing tide or current. Were the reactions of the boat and the water equal, the activity of the man would no more move the boat, than if he were ſitting at one end of it, and that activity were exerted in pulling a rope faſtened to the other: while on the other hand, if they were unequal, and that of the current the greateſt, the boat would move, notwithſtanding all the man's pulling, in the direction of the current. So that, inſtead of taking in the rope with his hands, he muſt let it out; or he would himſelf be pulled overboard and fall into the ſtream.

That the motions of the ſtone, in one caſe, and of the boat in the other, are not the only immediate effect of the action of the horſe, or the man, will be farther evident from conſidering the manner in which the motion of the animal itſelf is generated.

Firſt, it is induced from ſome motive, either apparent or occult, to move. It muſt, of neceſſity move one way—This direction is determined by the will, or the internal active power of the animal. But it does not actually move in conſequence of this determination. To put its deſign in execution it muſt preſs againſt ſome other reſiſting body. If it preſs in a direction contrary to that of its intended motion, and its centre of gravity reſt on a ſlippery ſurface, it will, of courſe, be moved by the reaction of the obſtacle in the direction intended. Thus a man, ſtanding on ſkaits upon the ice, may, by puſh-

ing with his hands or feet againſt a reſiſting obſtacle, cauſe it to move him, or as it is called, move himſelf, a conſiderable while, in a direction contrary to that he puſhed. But, in order to avoid the wear and tear of tender bodies moving on rough ſurfaces, the neceſſary conſequence of ſo much friction, nature has provided that the loco-motion of animals ſhould be progreſſive. It becomes neceſſary, therefore, that the centre of gravity ſhould alternately riſe and fall. A man may ſlip or ſlide, but he cannot walk or run, without raiſing his centre of gravity at every ſtep, in order to give it an inclination of deſcent in the direction of his motion.

This alternate riſe and fall of the centre of gravity is effected by the preſſure of the foot, in an oblique direction againſt the ground, to raiſe the body, and by the deſcent of the body when raiſed; during which the feet are alternately thrown forward to keep the animal from falling. Hence we ſee that its progreſſive motion in walking or running is ſo far from being the only immediate effect of its own motion, that it is not even the ſole effect of the reaction of the medium on which it acts, but the joint effect of that reaction and the action of gravity; in the compound direction of both which it moves.

And hence we ſee the reaſon why in pulling and drawing, effected by the alternate motion of the hands or feet, the power of the animal is ever proportional to its weight and the weight it ſuſtains. Thus in the caſe of the boat, the force with which it would oppoſe the water, would be proportional to the weight of the man pulling the rope. So that a heavy man, equally willing and active, would pull the boat a-ſhore, not only ſooner than a light one, but when a light one, of equal activity in proportion to his bulk, would not do it all. A light animal, be its ſtrength and activity what it will, cannot pull or draw ſo great a weight as an heavy animal of the ſame activity.

A practical and uſeful concluſion may be inferred from hence, not only reſpecting the properties of the animals beſt adapted for different kinds of labour; but alſo the method of applying thoſe properties to the greateſt advantage: every animal being capable only of exerting a power proportional to its weight, and the weight it is capable of ſupporting. It will, indeed, move its own limbs with an agility proportional to the elaſticity of its muſcles; but, cæteris

teris paribus, an heavy animal will always be ſtronger, or capable of greater labour than a light one; and that in proportion to their difference of weight. Hence we ſee, alſo, why men exert their greateſt ſtrength, either in carrying burthens, or in working engines, where the whole weight of the body is employed.

The doctrine of the equality of action and reaction, has been as imperfectly illuſtrated, with regard to the more immediate cauſe of motion by impulſe.

Thus, in rowing or puſhing along a barge, or lighter, by means of a pole; it is commonly ſaid the oars, in the one caſe, act againſt, or upon, the water in one direction; while the water, reacting on the oars, in a contrary direction produce the motion of the boat. In the other caſe, they ſay, that the reaction of the ground againſt the pole, makes the boat move. To theſe, it is objected, that the motion is in both caſes intirely produced by the man, whoſe active force is the only moving power. Profeſſor Stewart, ſays this, in contradiction to Sir Iſaac Newton.

As to the buſineſs of rowing, it is a compound action, conſiſting of both pulling and puſhing. A waterman pulls with one end of his oar, and puſhes with the other. Not to take up your time unneceſſarily, therefore, as I have already explained the mechaniſm of the former, I ſhall confine myſelf to the latter, viz. his puſhing a barge along with a pole. In this caſe he exerts the the ſame force as if he walked by the ſide of the canal and dragged the boat after him. The only difference in the operation is that, in walking along the ground and pulling his boat along, the man moves conſtantly as faſt as the boat, and may be conſidered as one body with it; being connected by the hawſer. Here the immediate cauſe of motion is the inequality between the reaction of the ground againſt one part of this compound body, and the oppoſite reaction of the water againſt another part of it: the generative force of the motion being ſtill merely the weight of the man. On the other hand, in puſhing the barge, the man does not move always with the ſame velocity, though he muſt be always conſidered as part of the ſame body. When he reſts with his ſhoulder on his pole, he may be conſidered, likewiſe, together with the barge

barge and pole, as one body with the ground; to which (notwithſtanding he moves his legs to keep himſelf from falling) he is attached, as well as to the barge; and does not move; though, by the action of his legs againſt the deck, the barge is partially moved from under him. When he takes up his pole, he is no longer one body with the ground, nor does he contribute to the motion of the barge. The immediate cauſe of which is, as before, the inequality between the reactions of the veſſel and the water, and the generative force merely the weight of the man, preſſing the ground, by means of the pole in one direction, and the water, by means of the barge, in another; in the compound of which two directions the barge moves; while the man himſelf deſcends in the line of gravity, and would fall flat on his face, if his centre were not repeatedly raiſed, by the alternate motion of his legs. Thus we ſee that, in this caſe, as in the former, neither the illuſtration nor the objection are ſtrictly applicable.

That the action or voluntary motion of the man originally determines in both, the direction in which the boat is to move, is admitted. But, ſo does that of the man at the helm, on board a ſhip; and yet nobody pretends that a ſhip is moved ſolely by its pilot. The wind or tide is at leaſt equally neceſſary. We are indeed our own pilots, Gentlemen; but, quo rapit tempeſtas—without aſſiſtance we can make no way, and even with it we cannot always make our own way.

On this conſideration, though merely a mechanical one, I flatter myſelf with your aſſiſtance, to enable me to remove that enormous weight of public prejudice, which prevails againſt the perpetual motion.

This, Gentlemen, I preſume to hope from your candour, as I have endeavoured to make it appear, as well as a ſingle lecture would permit, that motion is the mechanical effect of the phyſical action of the primary elements. That the direction of motion only comes within the province of animal intellect—That the vital ſyſtem is ſupported by mere mechanic motion; kept up by the elaſticity of the ſolids and the gravity of the fluids, compoſing the animal boody—That by the ſame means a more ſimple inanimate ſyſtem or machine may be framed; which may have the ſame property of continued action (or, as it is called, ſelf-motion) with the difference only of being incapable of thinking

thinking or diverſifying its action. And this is all that is, or can be, expected of a perpetual motion; the momentum of which may, for the reaſons before given, be encreaſed to any degree, according to the weight of the bodies employed, and the work required to be done.

If I have failed in any particular of giving conviction, a future lecture may probably elucidate what may ſeem obſcure in the preſent. In the mean time, I hope enough hath been ſaid, to convince my auditors, that I have not excited their attention to a ſubject I have not long conſidered; and that they will at leaſt conclude, in my favour, that a man of very moderate abilities may, during an intenſe application for fifteen or twenty years to one object, have taken a view of it in more lights, than the moſt ingenious philoſopher may have done, by making it only a curſory and occaſional object of his attention.

But here I muſt beg leave to put an end to the firſt part of my Lecture.

In my next (of which I ſhall take the liberty to give you early notice) I ſhall enter farther into the mechanical effects of motion: among which I place all the Phænomena, great and ſmall, of palpable bodies. Even their Extenſion, Gravitation, and Coheſion, with all their ſpecific differences, as alſo their various appearances under different circumſtances, I propoſe to prove to be the mechanical effects of one general principle of all natural perpetual motions; and that the very ſame on which I found my pretenſions to an artificial one: Indeed, if ſuch principle did not, or ſhould ceaſe to, exiſt in nature, we ourſelves, with all the objects around us,

Would, like the baſeleſs fabrick of a viſion,
Melt into air, into thin air.
The cloud-capt towers, the gorgeous palaces,
The ſolemn temples— the great globe itſelf
Yea, all which it inherit, would diſſolve,
And, like an inſubſtantial pageant fading,
Leave not a wreck behind.

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